

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 817 310 A3

(12)

EUROPEAN PATENT APPLICATION

(88) Date of publication A3:
05.04.2000 Bulletin 2000/14

(51) Int. Cl.⁷: H01Q 9/04, H01Q 5/00,
H01Q 21/06

(43) Date of publication A2:
07.01.1998 Bulletin 1998/02

(21) Application number: 97110394.0

(22) Date of filing: 25.06.1997

(84) Designated Contracting States:
**AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC
NL PT SE**

- Lee, Kuan M.
Brea, California 92621 (US)
- Chu, Ruey S.
Cerritos, California 90703 (US)

(30) Priority: 28.06.1996 US 678383

(71) Applicant: **RAYTHEON COMPANY**
Lexington, Massachusetts 02173 (US)

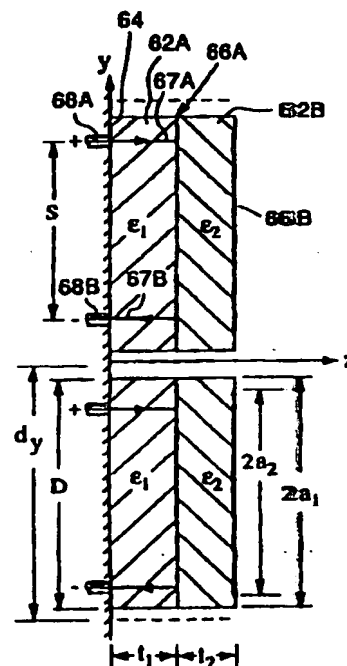
(74) Representative:
Stell, Christian, Dipl.-Ing. et al
Witte, Weller, Gahlert,
Otten & Stell,
Patentanwälte,
Rotebühlstrasse 121
70178 Stuttgart (DE)

(72) Inventors:

- Wang, Allen T.S.
Buena Park, California 90620 (US)

(54) **Wide-band/dual-band stacked-disc radiators on stacked-dielectric posts phased array antenna**

(57) A very wide-band or dual-band phased array antenna (50; 50'; 200) using stacked-disc radiators on stacked-dielectric cylindrical posts to form radiator elements (60; 60'; 210). Each radiator element includes a ground plane (64), a lower dielectric cylindrical post (62A) of a high dielectric material adjacent the ground plane (64), a lower thin conductive radiator disc (66A) formed on the upper surface of the lower dielectric post (62A), an upper dielectric cylindrical post (62B) of a low dielectric material disposed on top of the lower post (62A) and lower radiator disc (66A), and an upper thin radiator disc (66B) or annular ring (66B') formed on the upper surface of the upper post (62B). The first radiator disc (66A) is excited by two pairs of probes (67A-67D) arranged in orthogonal locations. Each pair of probes can be fed by coaxial cables with 180 degree phase reversal. The second radiator disc (66B) or annular ring (66B') is a parasitic radiator without feeding probes. Depending on the feed arrangement, the radiator elements can achieve single-linear polarization, dual-linear polarization or circular polarization.

**FIG. 2**

EP 0 817 310 A3

European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 11 0394

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US 5 010 348 A (RENE DIDIER ET AL) 23 Apr 11 1991 (1991-04-23) * column 2, line 43 - column 3, line 14 * * column 3, line 46-51; figures 3-5 *	1-10	H01Q9/04 H01Q5/00 H01Q21/06
X	WO 93 09613 A (CALLING COMMUNICATIONS CORP) 13 May 1993 (1993-05-13) * page 11, line 37 - page 12, line 20; figures 8-30 *	1-3, 10-12	
X	EP 0 449 492 A (HUGHES AIRCRAFT CO) 2 October 1991 (1991-10-02) * column 4, line 26-58 * * column 5, line 3-7, 35-47; figures 3, 4 *	1, 3, 10, 12	
A		2, 8	
X	US 5 497 164 A (CROO FREDERICE) 5 March 1996 (1996-03-05) * column 4, line 46 - column 5, line 7 * * column 5, line 50-54; figures 1-8 *	1, 3, 10	
A		8	TECHNICAL FIELDS SEARCHED (Int.Cl.6)
A	US 4 623 893 A (SABBAN ALBERT) 18 November 1986 (1986-11-18) * column 2, line 45-64 * * column 3, line 15-22; figures 1-3; table 1 *	1, 3, 9-12	H01Q
A	EP 0 521 377 A (BALL CORP) 7 January 1993 (1993-01-07) * column 5, line 32 - column 6, line 25 * * column 9, line 29-34 * * column 10, line 8-22, 36-43 * * column 11, line 51 - column 12, line 13; figures 1, 2, 6 *	1, 3, 8, 10, 12	
		-/-	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 11 February 2000	Examiner Ribbe, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EP 0 817 310 A3



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 97 11 0394

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	EP 0 279 050 A (BALL CORP) 24 August 1988 (1988-08-24) * page 5, line 41-56 * * column 11, line 27-31; figures 1-5 *	1-3,9-11	
E, L	EP 0 886 336 A (HUGHES ELECTRONICS CORP) 23 December 1998 (1998-12-23) * column 3, line 15-58; figures 1-7 *	1-12	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
Place of search THE HAGUE		Date of completion of the search 11 February 2000	Examiner Ribbe, J
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document</p> <p>T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document</p>			

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 97 11 0394

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-02-2000

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5010348	A	23-04-1991	FR 2623020 A	12-05-1989
			CA 1290449 A	08-10-1991
			DE 3886689 D	10-02-1994
			DE 3886689 T	28-04-1994
			EP 0315141 A	10-05-1989
			JP 1205603 A	18-08-1989
WO 9309613	A	13-05-1993	AT 182729 T	15-08-1999
			AU 3054992 A	07-06-1993
			CA 2121587 A	13-05-1993
			DE 69229678 D	02-09-1999
			EP 0611500 A	24-08-1994
			EP 0935349 A	11-08-1999
			US 5736959 A	07-04-1998
EP 0449492	A	02-10-1991	US 5006859 A	09-04-1991
			CA 2037451 A	29-09-1991
			DE 69107491 D	30-03-1995
			DE 69107491 T	09-11-1995
			JP 4223705 A	13-08-1992
US 5497164	A	05-03-1996	FR 2706085 A	09-12-1994
			DE 69413882 D	19-11-1998
			DE 69413882 T	02-06-1999
			EP 0627783 A	07-12-1994
			ES 2125420 T	01-03-1999
US 4623893	A	18-11-1986	NONE	
EP 0521377	A	07-01-1993	US 5210542 A	11-05-1993
			CA 2071325 A	04-01-1993
			JP 5218729 A	27-08-1993
EP 0279050	A	24-08-1988	US 4835538 A	30-05-1989
			AT 92673 T	15-08-1993
			CA 1287917 A	20-08-1991
			DE 3786913 A	09-09-1993
			DE 3786913 T	10-03-1994
			JP 63189002 A	04-08-1988
EP 0886336	A	23-12-1998	US 5880694 A	09-03-1999
			CA 2240029 A	18-12-1998

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 817 310 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

07.01.1998 Bulletin 1998/02

(51) Int. Cl.⁶: H01Q 9/04, H01Q 5/00,
H01Q 21/06

(21) Application number: 97110394.0

(22) Date of filing: 25.06.1997

(84) Designated Contracting States:

AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC
NL PT SE

(30) Priority: 28.06.1996 US 678383

(71) Applicant:

HE HOLDINGS, INC. dba HUGHES
ELECTRONICS
Los Angeles, CA 90045-0066 (US)

(72) Inventors:

• Wang, Allen T.S.
Buena Park, California 90620 (US)

• Lee, Kuan M.

Brea, California 92621 (US)

• Chu, Ruey S.

Cerritos, California 90703 (US)

(74) Representative:

Steil, Christian, Dipl.-Ing. et al
Witte, Weller, Gahlert,
Otten & Steil,
Patentanwälte,
Rotebühlstrasse 121
70178 Stuttgart (DE)

(54) Wide-band/dual-band stacked-disc radiators on stacked-dielectric posts phased array antenna

(57) A very wide-band or dual-band phased array antenna (50; 50'; 200) using stacked-disc radiators on stacked-dielectric cylindrical posts to form radiator elements (60; 60'; 210). Each radiator element includes a ground plane (64), a lower dielectric cylindrical post (62A) of a high dielectric material adjacent the ground plane (64), a lower thin conductive radiator disc (66A) formed on the upper surface of the lower dielectric post (62A), an upper dielectric cylindrical post (62B) of a low dielectric material disposed on top of the lower post (62A) and lower radiator disc (66A), and an upper thin radiator disc (66B) or annular ring (66B') formed on the upper surface of the upper post (62B). The first radiator disc (66A) is excited by two pairs of probes (67A-67D) arranged in orthogonal locations. Each pair of probes can be fed by coaxial cables with 180 degree phase reversal. The second radiator disc (66B) or annular ring (66B') is a parasitic radiator without feeding probes. Depending on the feed arrangement, the radiator elements can achieve single-linear polarization, dual-linear polarization or circular polarization.

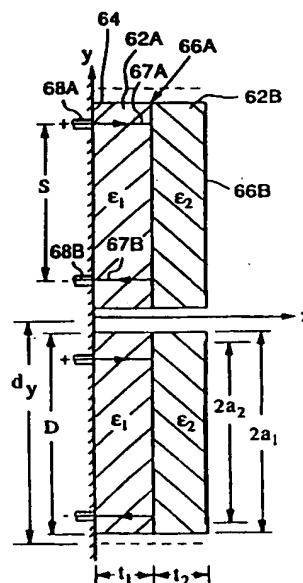


FIG. 2

Description

TECHNICAL FIELD OF THE INVENTION

This invention relates to phased array antennas, and more particularly to a wide-band or dual-band array antenna using stacked-disc radiators on stacked cylindrical dielectric posts.

BACKGROUND OF THE INVENTION

There is a need in the ship, submarine, and airborne satellite communication or radar fields for a wide-band or dual-band phased array antenna with dual-linear or circular polarization. In the open literature, there are described some microstrip disc patch array antenna designs, but these designs show very limited capabilities in the bandwidth and/or scan coverage performances. See, "Microstrip Array Technology," Robert J. Mailloux et al., IEEE Antennas and Propagation Transactions, Vol. AP-29, January 1981, pages 25-37. Phased arrays have been developed which use a disc radiator on a dielectric post, but these arrays have limited bandwidth, on the order of 20%.

SUMMARY OF THE INVENTION

A radiator structure for use at microwave frequencies is described, and includes a ground plane, and a lower dielectric post having a lower surface disposed adjacent the ground plane and an upper surface. A thin lower radiator element is disposed on the upper surface of the lower dielectric post. An upper dielectric post having a lower surface and an upper surface is stacked on the lower radiator element. An upper thin radiator element is disposed on the upper surface of the upper dielectric post. The radiator structure further includes a pair of spaced probes in electrical contact with the lower radiator element for exciting the lower radiator. The upper radiator element is not fed by feed probes and is a parasitic radiator element. A feed network supplies first and second excitation signals to respective ones of the probes which are 180 degrees out of phase.

A second pair of excitation probes can be arranged in orthogonal locations relative to locations of the first pair of probes. The feed network further supplies third and fourth excitation signals to respective ones of the second pair of probes which are 180 degrees out of phase with each other.

In a preferred embodiment, the lower and upper dielectric posts have a cylindrical configuration, and are of equal diameter. The lower radiator element is a circular disc of electrically conductive material. In one wide-band embodiment, the upper radiator element is also a circular disc of electrically conductive material. In an alternate embodiment, the upper radiator element is an annular ring of electrically conductive material. Both embodiments can provide wide-band or dual-band per-

formance.

The radiator structure is used in a phased array antenna, wherein a plurality of the radiator structure units are arranged for phased array operation. In one array embodiment, the radiator units are arranged in a rectangular lattice structure. In another array embodiment, the radiator units are arranged in an equilateral triangular lattice configuration.

BRIEF DESCRIPTION OF THE DRAWING

These and other features and advantages of the present invention will become more apparent from the following detailed description of an exemplary embodiment thereof, as illustrated in the accompanying drawings, in which:

FIG. 1 is a top view of an exemplary embodiment of a stacked-dielectric cylindrical post phased array antenna embodying this invention.

FIG. 2 is a cross-sectional view taken along line 2-2 of FIG. 1.

FIG. 3 illustrates an alternate embodiment of the invention, wherein the top disc radiator of FIG. 1 is replaced with an annular ring radiator.

FIG. 4 is a cross-sectional view taken along line 4-4 of FIG. 3.

FIG. 5 illustrates a feed configuration for one linear-polarization dual-band operation.

FIG. 6 illustrates a feed configuration for dual-band, circular polarization operation.

FIG. 7 shows the phased array arranged in equilateral triangular lattice structure.

FIG. 8 illustrates the computed active return loss as a function of frequency for broadside scan.

FIG. 9 illustrates the active return loss as a function of frequency for the H-plane scan case.

FIG. 10 illustrates the active return loss as a function of frequency for the E-plane scan case.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a simplified top view of a portion of an exemplary stacked-dielectric cylindrical post phased array antenna 50 embodying this invention. The portion of the exemplary array 50 shown in FIG. 1 includes four radiating elements or unit cells 60, 70, 80 and 90. Of course, array antennas embodying the invention can include much larger numbers of the radiating elements. The element spacings d_x and d_y are the same and are in rectangular lattice configuration.

The unit cells are identical, and only cell 60 will be described in detail, the other unit cells 70, 80 and 90 being identical to unit cell 60. There are two cylindrical dielectric posts in each unit cell. Thus, cell 60 includes lower dielectric post 62A and upper dielectric post 62B. Both dielectric posts 62A, 62B have the same diameter

D. The lower dielectric post 62A is fabricated from a material having a high dielectric constant ϵ_1 and a height t_1 , and is disposed on the ground plane 64. An exemplary material suitable for the lower disc is "Stycast Hi-K" dielectric material marketed by Emerson and Cuming.

Positioned on top of the lower post 62A is the first disc radiator 66A of radius a_1 . This disc radiator is excited by two pairs of probes, 67A-67B and 67C-67D arranged in orthogonal locations. The probe separation is S for each pair. Each pair of probes is fed by a pair of coaxial cables 68A-68B and 68C-68D, with 180 degree phase reversal.

The upper dielectric post 62B is fabricated of a material having a low dielectric constant ϵ_2 and a height t_2 , and is disposed on top of the first disc radiator 66A. A material suitable for use as the upper dielectric post is a low density dielectric foam, such as "Stycast Lo-K" material marketed by Emerson and Cuming. A second disc radiator 66B of radius a_2 is in turn positioned on top of the second dielectric post 62B. This upper disc radiator is a parasitic radiator without feeding probes. The parasitic radiator 66B is for tuning to high-band frequencies so that the entire bandwidth is extended from low-band to high-band.

The two pairs of excitation probes 67A-67B and 67C-67D provide dual-linear polarization and circular polarization capability. The pairs of probes (for example, vertical polarization and horizontal polarization) are orthogonal to one another. Consequently, they produce orthogonal polarizations. Two orthogonal linear polarizations can be combined to produce circular polarization.

The lower radiator element is tuned for operation (has a resonance) at a lower frequency. The upper radiator element is tuned for operation at (has a resonance) at a higher frequency. Wide-band performance is obtained by tuning the upper radiator element so that its resonance is close in frequency to that of the lower radiator element. Dual-band operation is achieved when the resonances of the lower and upper radiator elements are separated in frequency sufficiently to form distinct frequency bands, with relatively poor performance at frequencies intermediate the two bands.

FIG. 3 illustrates an alternate embodiment of the invention, wherein the top disc radiator 66B of the embodiment of FIG. 1 is replaced with an annular ring radiator. Thus, the array system 50' of FIG. 3 employs an annular ring radiator 66B'; the annular ring radiator is also a parasitic radiator without feeding probes. The annular ring radiator has an inner circumference of radius b_2 and an outer circumference of radius a_2 . This annular ring parasitic radiator 66B' provides a different frequency tuning effect than that of the solid disc radiator 66B.

FIG. 5 illustrates a feed configuration 100 for one exemplary linear-polarization dual-band operation. One pair of the feed probes of each element is fed by a 180

degree phase reversal device. Thus, the feed probes 67A-67B of exemplary element 60 are fed by a 180 degree phase reversal (equal power) balun or 180 degree (equal power) hybrid 102. The feed probes 87A-87B of adjacent element 80 are fed by a 180 degree phase reversal balun or 180 degree hybrid 110. The input port 102A of the feed balun is connected to a diplexer 104. Two output ports of the diplexer 104 are the high-band port 104A and the low-band port 104B. Similarly, the input port 110A of the feed balun 110 is connected to a diplexer 112. Two output ports of the diplexer 112 are the high-band port 112A and the low-band port 112B. Each high-band port is connected to a high-band phase shifter and then to the high-band corporate feed network. Thus, port 104A is connected to high-band phase shifter 106 and then to the high-band corporate feed network. Port 112A is connected to high-band phase shifter 114 and then to the high-band corporate feed network. Two low-band ports from two adjacent elements in the azimuth direction and two in the elevation direction are combined (to reduce the component count), and these azimuth and elevation ports are further combined into one output. For example, low-band ports 104B and 112B are combined at combiner 116 to form an azimuth signal at port 116A. The low-band ports 122B and 132B from other adjacent elements (not shown in FIG. 5) are combined at combiner 126 to form an elevation signal at port 126A. Outputs 116A and 126A are combined at combiner 117 to produce output 117A. This output 117A is then connected to low-band phase shifter 118 and further connected to a low-band corporate feed network. A similar circuit can be made to excite the orthogonal linear polarization probes of the radiating elements to obtain dual linear polarization operation.

The feed configuration 100 can be modified from dualband to wide-band operation by removing the diplexers 104 and 112, and combiners 116, 117, 126, so that the respective balun outputs are connected directly to respective (wide band, in this case) phase shifters.

FIG. 6 illustrates a feed configuration 150 for dual-band, circular polarization operation. The four probes of each disc radiator need to be excited in phase sequence as shown in FIG. 6. This can be achieved by feeding two orthogonal pairs by two 180 degree hybrids and combining the outputs with a 90 degree hybrid circuit. Consider the example of disc radiator 66A of element 60, fed by probe pairs 67A-67B and 67C-67D. The probe 67A is to be fed with a feed signal of 90 degrees relative phase, the probe 67B with a feed signal of 270 degrees relative phase, the probe 67C with a feed signal of 180 degrees relative phase, and the probe 67D with a feed signal of 0 degrees relative phase. The feed configuration 150 comprises 180 degree hybrids 152 and 154, 90 degree hybrid 156, and diplexer 158 with high-band input port 158A, low-band port 158B and input/output port 158C. The feed configuration 150 can be modified to wide-band operation by removing the

diplexer 158. For a wide-band transmit operation, the signal at 158C is divided (equally) in power by hybrid 156, and the signal at port 156B of 90 degrees phase relative to the signal at 156A. The signal at 156A is divided in power at hybrid 154, with the signal at port 154B at 180 degrees phase relative to the signal at 154A. The signal at 156B is divided in power at hybrid 152, with the signal at port 152B of 180 degrees phase relative to the signal at 152A. As a result, the signal at port 152A is at 90 degrees phase relative to the signal at port 154A. The ports of the 180 degree hybrids are connected to corresponding probes by equal length coaxial cables. Thus, the desired phasing of the feed signals is achieved.

FIG. 7 shows a phased array 200 embodying the invention, and arranged in equilateral triangular lattice structure. This will improve some scan performance in the principal plane cuts. The array 200 includes seven exemplary unit cells 210-270 of the stacked-disc radiators on stacked-dielectric posts, with cells 210-260 arranged about a center cell 270.

An example of the design for linear polarization with single-pair probe excitation in accordance with this invention is given as follows: $d_x = d_y = 0.3278$ inches in rectangular lattice,

the dielectric post diameter $D = 0.3105$ inches;

the lower dielectric post $t_1 = 0.0800$ inches and dielectric constant $\epsilon_1 = 6.50$;

the upper dielectric post $t_2 = 0.0828$ inches and dielectric constant $\epsilon_2 = 1.4$;

the lower disc radiator $a_1 = 0.138$ inches, and the probe separation $S = 0.1656$ inches;

the upper disc radiator $a_2 = 0.1311$ inches.

The computed active return loss for this exemplary linear polarization example as a function of frequency for broadside scan ($\theta = 0$ degrees scan) is given in FIG. 8. The active return loss is below -10 dB for the frequency band from 7 GHz to 15 GHz. FIG. 9 illustrates the input active return loss as a function of frequency for H-plane scan case (at $f = 7$ GHz, scan = 40 degrees; at $f = 15$ GHz, scan = 17.5 degrees). For the E-plane scan case (scan = 40 degrees at $f = 7$ GHz; scan = 17.5 degrees at $f = 15$ degrees), the input active return loss as a function of frequency is given in FIG. 10.

There has been described a very wide-band or dual-band phased array antenna system using stacked-disc radiators on stacked-dielectric cylindrical posts. The polarization of the array can be single-linear, dual-linear, or circular polarization depending on whether using single-pair or double-pairs of probe excitations. The array is low-profile, compact and rigid, and its bandwidth in exemplary applications can be 2:1 over a wide scan volume. While the exemplary embodiments illustrated herein have employed cylindrical dielectric posts and circular disc elements, other configurations can be used, depending on the application. These other config-

urations include, but are not limited to, elliptical or rectangular cross-sectional configurations for the posts and radiator conductor elements. Further, while the disclosed embodiments have employed two radiator elements stacked with two dielectric posts, one or more additional radiator element/dielectric posts can be added to each unit radiating cell to achieve even higher bandwidth.

It is understood that the above-described embodiments are merely illustrative of the possible specific embodiments which may represent principles of the present invention. Other arrangements may readily be devised in accordance with these principles by those skilled in the art without departing from the scope and spirit of the invention.

Claims

1. A radiator structure for use at microwave frequencies, characterized by:

a ground plane (64);

a lower dielectric post (62A) having a lower surface disposed adjacent the ground plane (64) and an upper surface;

a thin lower radiator element (66A) disposed on said upper surface of said lower dielectric post (62A); an upper dielectric post (62B) having a lower surface and an upper surface, said upper dielectric post (62B) stacked on said lower radiator element (66A);

an upper thin radiator element (66B; 66B') disposed on said upper surface of said upper dielectric post (62B); and

at least one pair of spaced probes (67A, 67B, 87A, 87B) in electrical contact with said lower radiator element (66A) for exciting the lower radiator element (66A), wherein the upper radiator element (66B; 66B') is not fed by feed probes and is a parasitic radiator element (66B; 66B').

2. The radiator structure of claim 1, characterized in that said lower and upper dielectric posts (62A, 62B) have a cylindrical configuration.
3. The radiator structure of any of the preceding claims, characterized in that said lower radiator element (66A) is a circular disc (66A) of electrically conductive material.
4. The radiator structure of any of the preceding claims, characterized by a feed network (100) for supplying first and second excitation signals to respective ones of said probes (67A, 67B, 87A, 87B), said excitation signals 180 degrees out of phase.

5. The radiator structure of any of the preceding claims, characterized by a second pair of excitation probes (67C, 67D) arranged in orthogonal locations relative to locations of said first pair of probes (67A, 67B). 5
6. The radiator structure of claim 5, characterized by a feed network (150) for supplying first and second excitation signals (152A, 152B) to respective ones of said first pair of probes (67A, 67B), said first and second excitation signals (152A, 152B) 180 degrees out of phase, and for supplying third and fourth excitation signals (154A, 154B) to respective ones of said second pair of probes (67C, 67D), said third and fourth excitation signals (154A, 154B) 180 degrees out of phase with each other. 10 15
7. The radiator structure of claim 6, characterized in that said first and second excitation signals (152A, 152B) produce a first linear polarization excitation, and said third and fourth excitation signals (154A, 154B) produce a second linear polarization which is orthogonal to said first linear polarization excitation. 20
8. The radiator structure of claim 6, characterized in that said respective excitation signals (152A, 152B, 154A, 154B) are phased to provide circular polarization operation. 25
9. The radiator structure of any of claims 1 - 8, characterized in that said upper radiator element is an annular ring (66B) of electrically conductive material. 30
10. The radiator structure of any of claims 1 - 8, characterized in that said upper radiator element is a circular disc (66B) of electrically conductive material. 35
11. The radiator structure of any of the preceding claims, characterized in that said lower dielectric post (62A) is fabricated of a high dielectric material, and said upper dielectric post (62B) is fabricated of a low dielectric material. 40
12. The radiator structure of any of the preceding claims, characterized in that said structure is in a phased array antenna (50; 50'; 200) comprising a plurality of said radiator structures (60, 70, 80, 90; 60', 70', 80', 90'; 210-270) arranged in a spaced configuration. 45 50

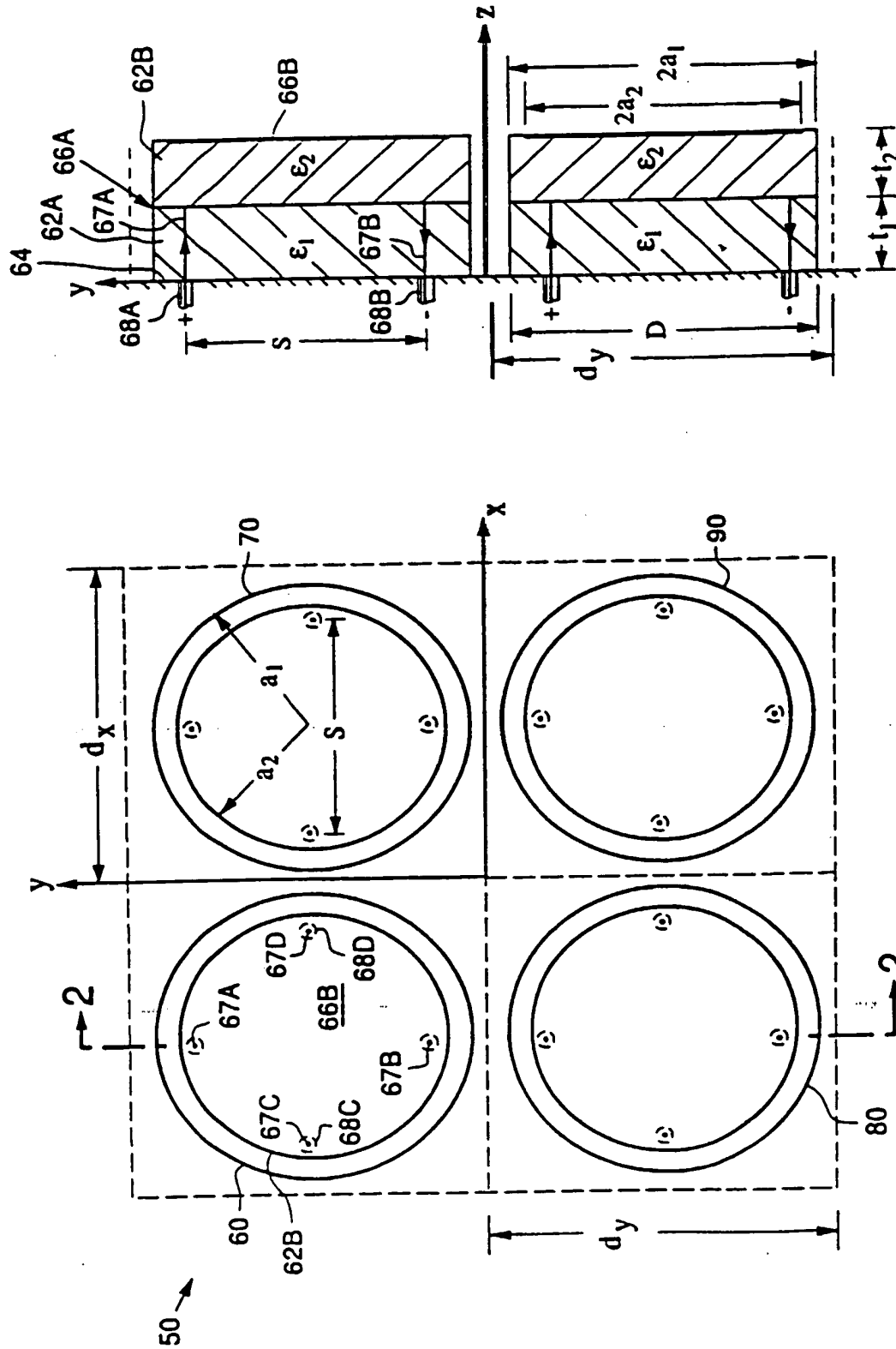


FIG. 1

FIG. 2

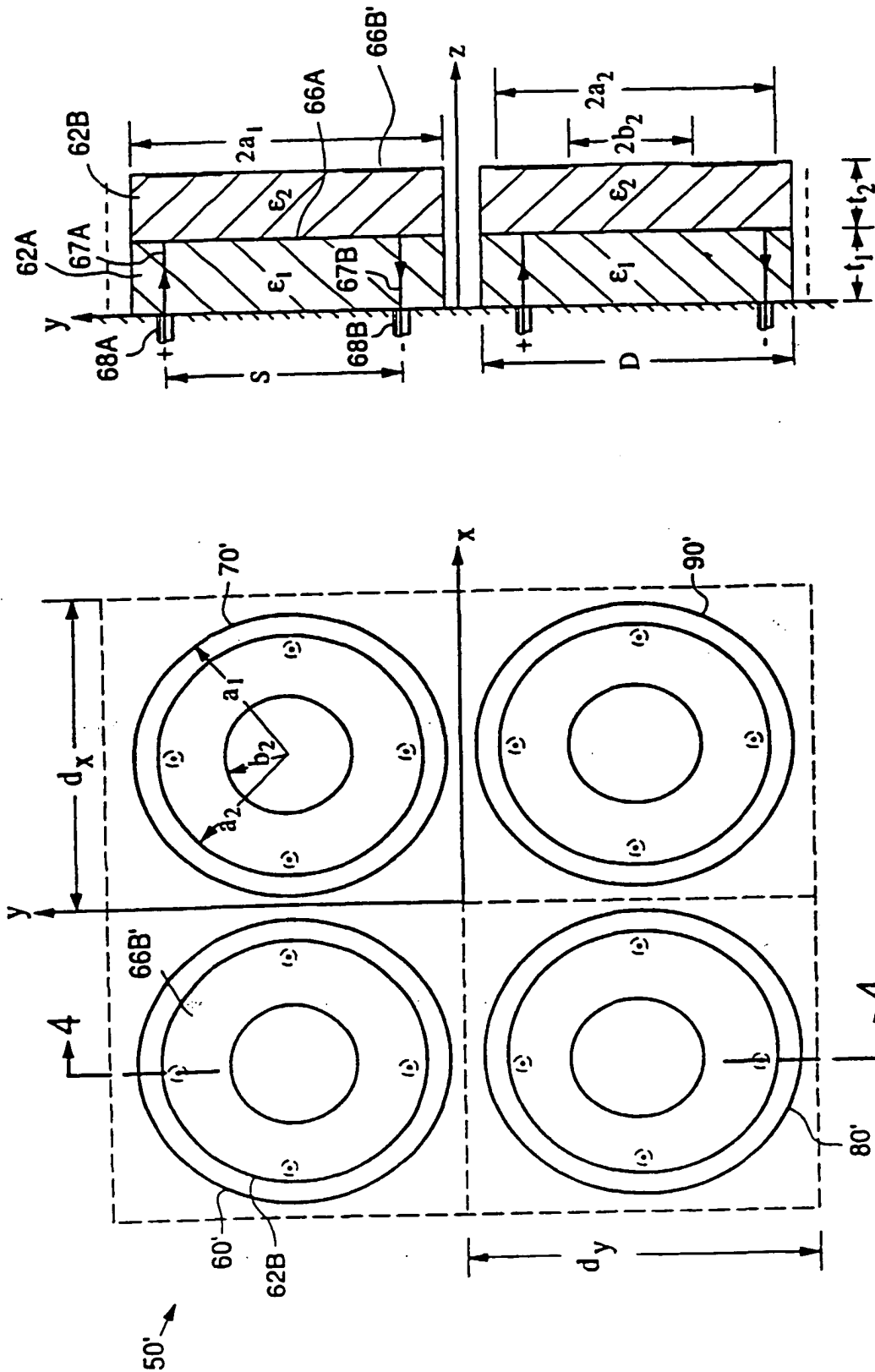


FIG. 4

FIG. 3

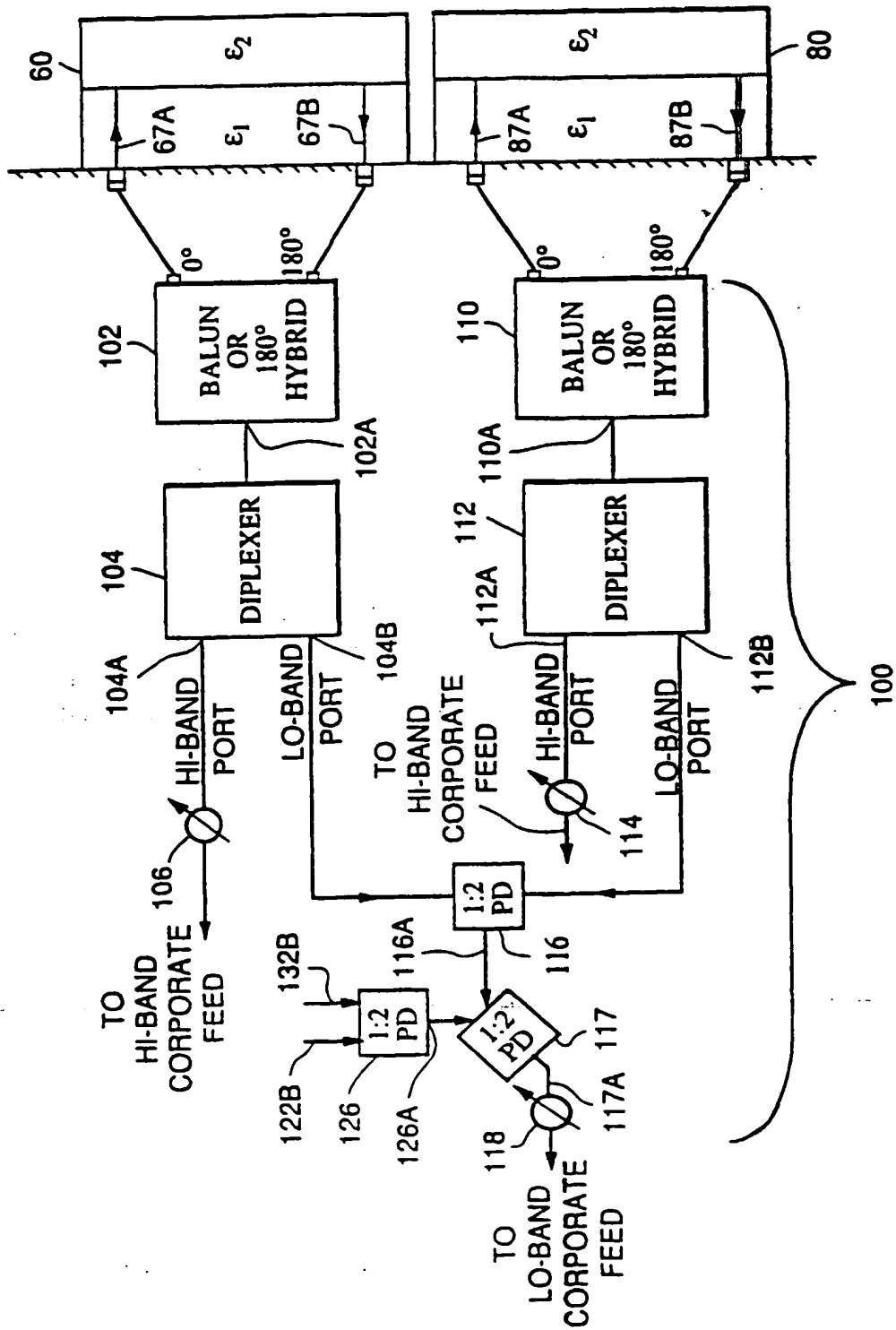


FIG. 5

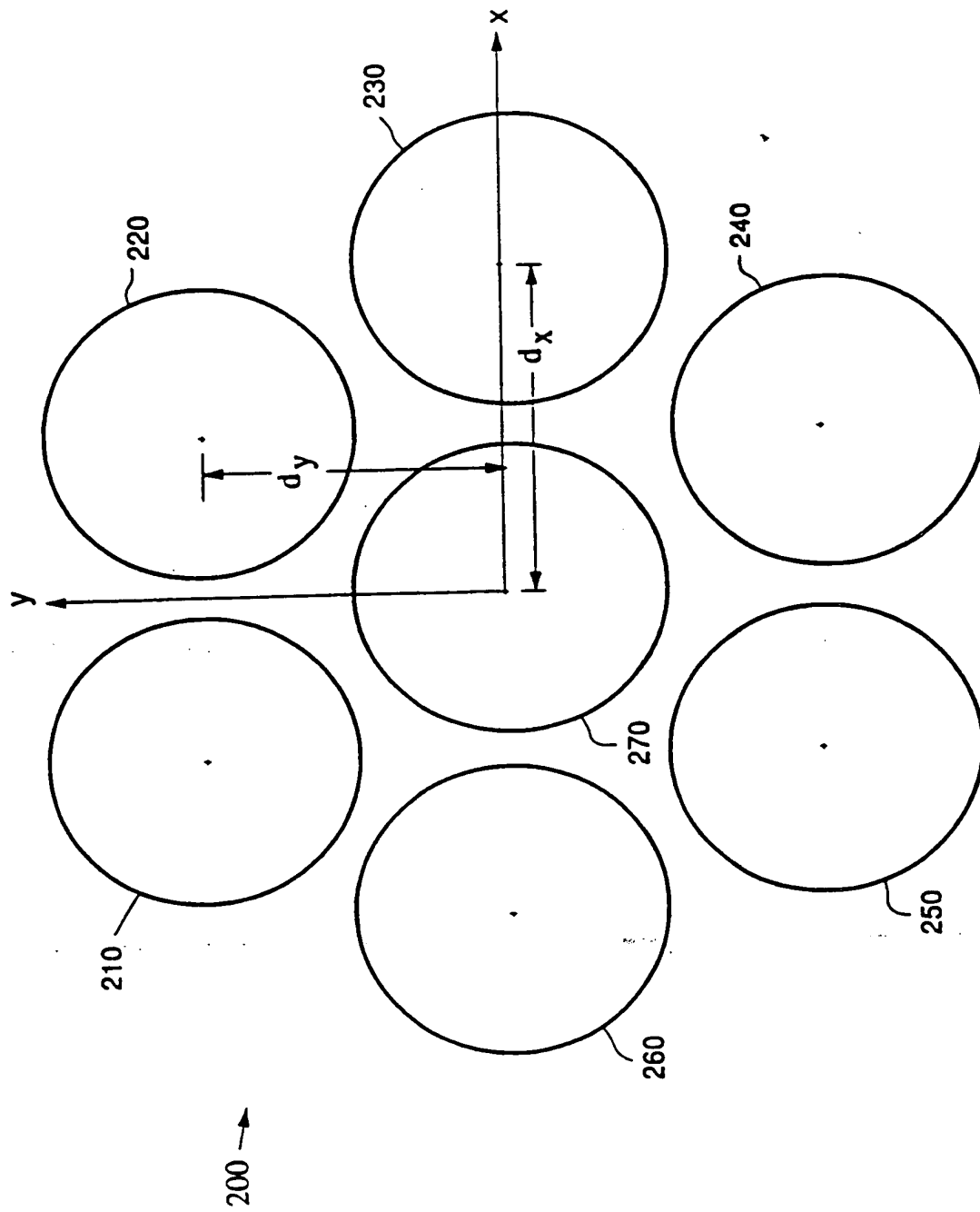


FIG. 7

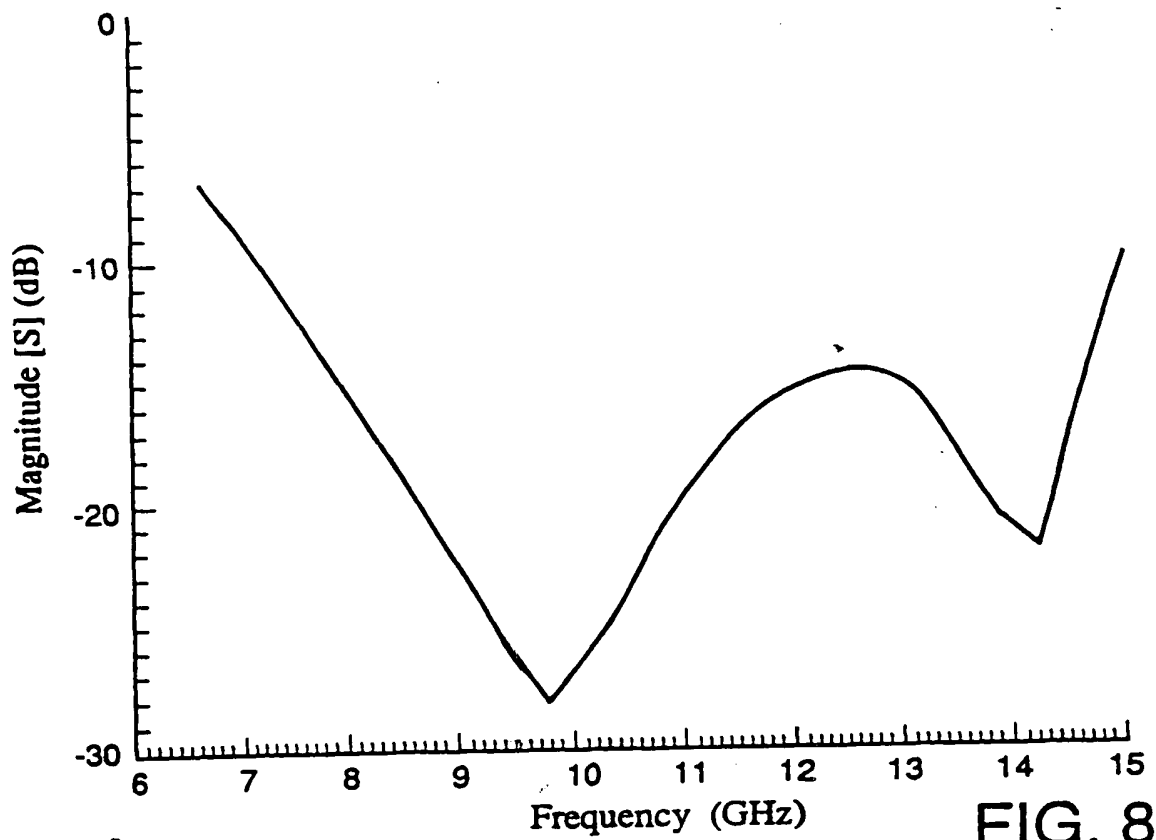


FIG. 8

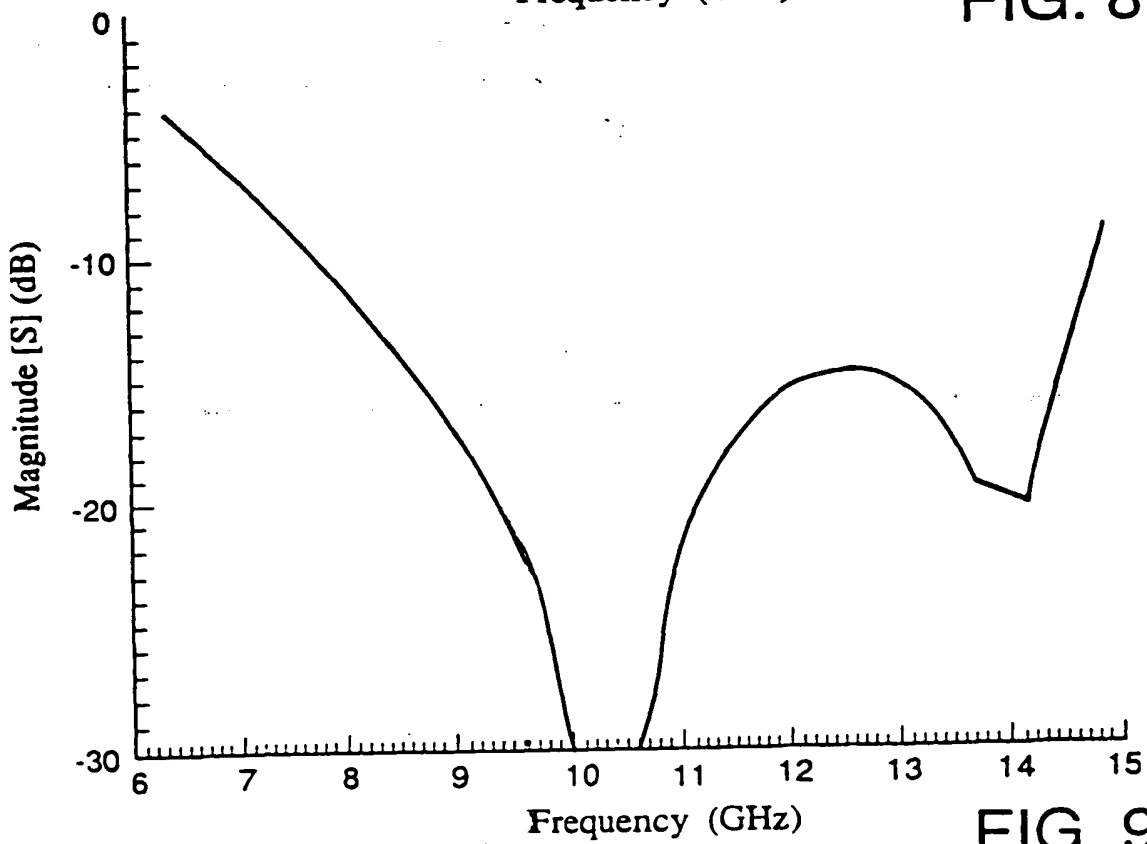


FIG. 9

FIG. 6

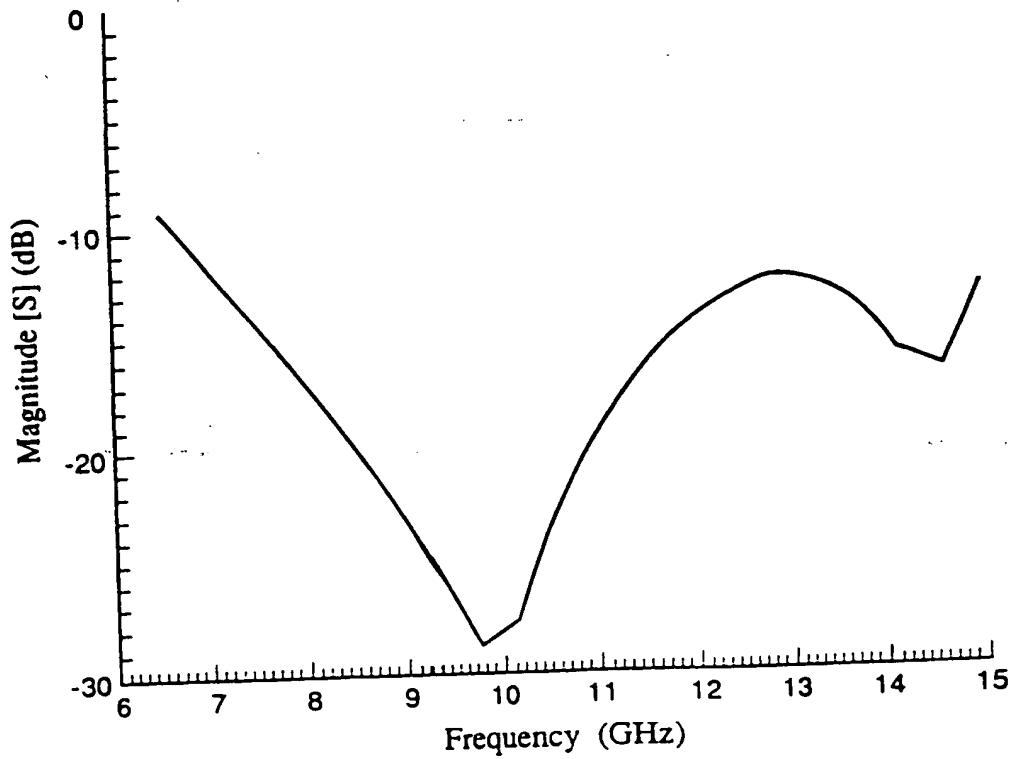
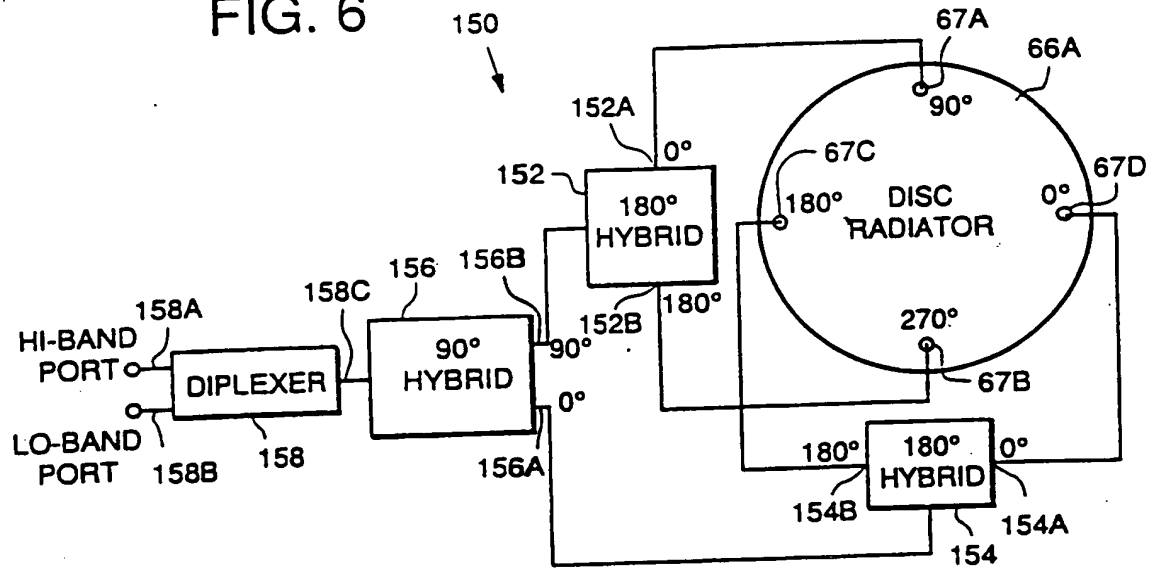


FIG.10